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ORIGINAL PAPER

Correlation between the avian community and habitat at different water levels during spring migration in Zhalong National Nature Reserve, China

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Abstract: Zhalong National Nature Reserve (Zhalong) is an important stopover for migratory birds. In recent decades, Zhalong has become the focus of researchers and public discussion in relation to irrigation. We studied relationships between birds and habitats at different water levels to guide development of more effective habitat management measures. We used line transects to survey bird numbers and distribution during April-May from 2005-2009 at Zhalong, and used cluster analysis and Chi-Square tests to analyze data. We recorded 139 bird species of 39 families and 13 orders during spring migration, including Anseriformes, Charadriiformes, Ciconiiformes, Columbiformes, Coraciiformes, Cuculiformes, Falconiformes, Galliformes, Gruiformes, Passeriformes, Piciformes, Podicipediformes, Strigiformes. Dominant vegetation and geographic region were the main influence factors of avian distribution. Different ecological groups preferred different water levels (p<0.01) and different habitat types (p<0.01). Grallatores, Natatores and Passeres were the main ecological groups in different wetland habitats, and reed marsh and lake are the main habitats for management. Grallatores preferred reed marsh and lake with water levels >30 cm and 5−15 cm. Natatores preferred lakes with deep water (>30 cm). Passeres preferred open forest and reed marsh with no surface water. Different avian ecological groups occupied specific habitats depending on water level and we recorded some overlaps in bird distribution.

Key words: avian community; ecological group; spring migration season; water level; Zhalong reserve

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Introduction

For migratory birds, spring migration period is a key stage of life history (Senner et al. 1981). Migration staging or stopover sites during spring are important for energy supply and rest of migratory birds. These factors determine survival during avian migration and the population dynamics and species diversity of the avian community (Mcneil and Cadieux 1972; Morrison 1984; Timothy and Christiaan 2002).

Zhalong National Nature Reserve (Zhalong) in northeast China is a Ramsar Wetland of International Importance (Zou et al. 2003), also an important stopover in the migratory route of East Asian-Australasian flyway. Since the 1990s, the wetland environment has degraded due to declining water levels (Cui et al. 2006; Wang et al. 2006; Wu and Zou 2011) caused by natural and human disturbances, including drought, annual wildfire, reed harvest, fishing, engineering construction, and wetland conversion, (Wang et al. 2010) . In 2001, Zhalong installed water control infrastructure to supply more water to the reserve. By 2008, 1,150 million m^3 of water was supplied to the reserve and the environment wetland habitat quality, especially the diversity of water levels improved. Numbers of migrating waterbird at Zhalong subsequently increased. Increased water supply significantly influenced the species diversity and the population structure in the reserve. However, study of the relationship between water supply and the avian community dynamic were few.

We hypothesized the existence of a relationship between the avian community and water levels in various habitats. This study is useful for scientific management of the avian community at Zhalong based on provision of habitats with varying water levels, and also for establishing a scientific monitoring network to protect waterfowl.

Materials and methods

Site description

Zhalong (46°52′–47°32′N, 123°47′–124°37′E) is located in Heilongjiang Province, China, and it was listed as a Ramsar "Wetland of International Importance" (especially as waterfowl habitat) in 1992 (Zou and Wu 2006). The region belongs to the continental, semiarid and monsoon climate. Total area of the reserve is 2,100 km^2 with average elevation of 144.0 m above sea level. Reed marshes cover an area of 80%–90% of the reserve, while *Carex* swamp (*Carex pseudoeuraica* swamp and bulrush swamp), meadows, and grassland make up the remainder (Wu and Zou 2009; Zou and Wu 2009). The wetland habitats are suitable as main stopovers for birds during spring migration. Reed marshes in the wetland are also a primary economic resource for local people.

Our surveys focused on three observation sites within the reserve (Fig. 1): Zhalong, Laomachang, and Dangnai.

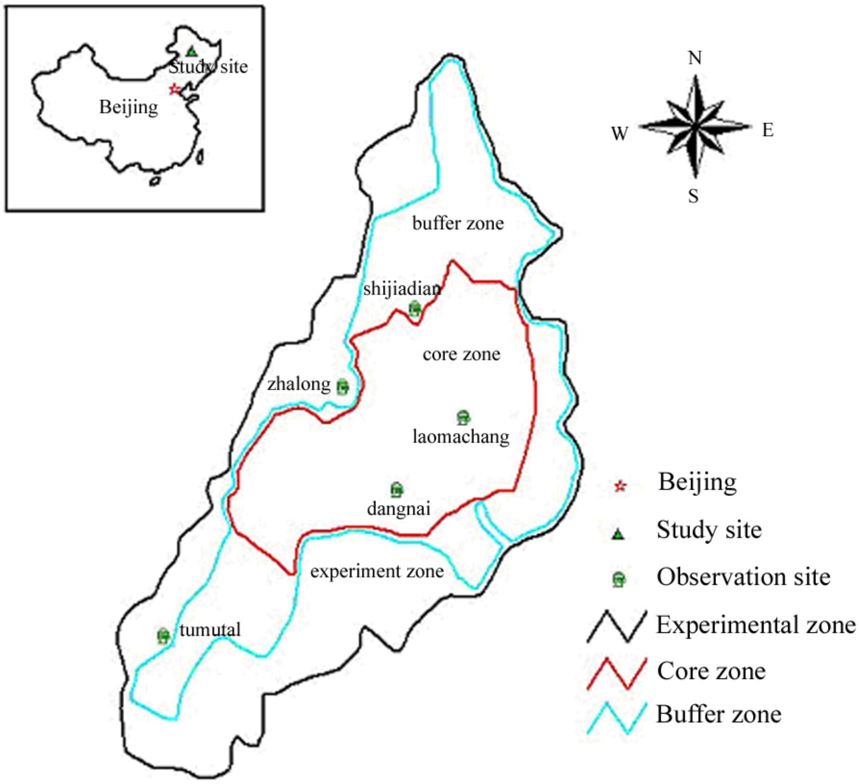

Fig. 1 Location map of the observation site in Zhalong reserve

Data collection

From March to May 2005–2009, we recorded bird and species numbers in 101 sample areas in different habitat types (14 sample areas in water areas, 53 in reed marsh, 10 in *Carex pseudocuraica* marsh, 9 in meadow, 8 in farmland, and 7 in open forest) by line-transect sampling, square sampling, circle sampling and point sampling methods. We used 820x binoculars and 20–60x spotting scopes. We used point sampling and square sampling methods at water areas, with 2–4 observation points per water area, and 10–15 minutes per observation point. We used line sampling methods in reed marsh, *Carex pseudocuraica* marsh, meadows and farmland, with 2-km transect lengths in theory, and the survey speed was 2–3 km/h on foot in theory. We used square sampling plots in open forest with 2-3 km/h speed on foot.

Field surveys were conducted once per month for 7–10 days. We sampled plots/transects at the same time of day each month and sampled on days with no wind or little wind. We measured water depth in different habitat types and recorded bird species and numbers.

Avian ecological group

There are eight avian ecological groups in the world, of which six ecological groups are distributed in Zhalong reserve: Natatores (N), Grallatores (G), Terrestores (T), Raptatores (R), Scansores (S) and Passeres (P).

Water level

Irrigation at Zhalong wetland is mainly implemented in spring migration season and the season of avian breeding. Water level

(WL) in this paper was defined as water depth in five classes, and mainly based on the Cluster result of the leg length of waterfowl recorded at Zhalong. The cluster result (Fig. 2) showed that all waterfowl recorded at Zhalong were clustered into three classes. Basing on the cluster result, we calculated the leg length of each cluster of waterfowl (Table 1), and took the maximum value of every cluster as the threshold value of water level. In this paper, we regarded 0 centimeter water level as a special value. So, the water levels in this paper were divided into four classes, namely 0 cm, 5 cm (5.73 cm), 15 cm (15.24 cm), 30 cm (28.61cm), and five water level intervals, namely 0 cm water level (no surface water) (WL0), 0−5 cm water depth (WL1), 5−15 cm water depth (WL2), 15−30 cm water depth (WL3), and more than 30 cm water depth (WL4).

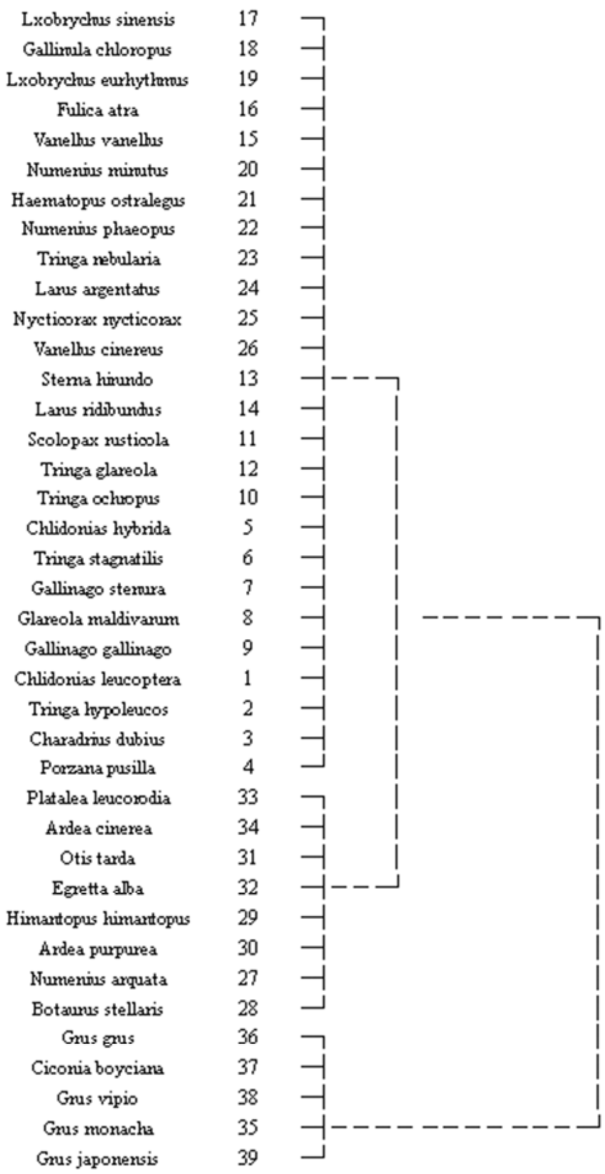

Fig. 2 Cluster of waterfowl leg length monitored at Zhalong

Data analysis

Data were analyzed using SPSS 11.5 software. First, we analyzed the data of different avian ecological groups monitored in different water level habitats (five water level gradients and six habitat types) by total bird numbers and density. Then, we analyzed the correlation between different avian ecological groups and various water level classes by chi-squared test.

Table 1. Leg length of three cluster waterfowl monitored

Cluster	Species number	Species name	Leg length/cm (average ± standard error)	Interval/cm (minimum, maximum)
1	26	*Chlidonias leucoptera*, *Tringa hypoleucos*, *Charadrius dubius*, *Porzana pusilla*, *Chlidonias hybrida*, *Tringa stagnatilis*, *Gallinago stenura*, *Glareola maldivarum*, *Gallinago gallinago*, *Tringa ochropus*, *Scolopax rusticola*, *Tringa glareola*, *Sterna hirundo*, *Larus ridibundus*, *Vanellus vanellus*, *Fulica atra*, *Lxobrychus sinensis*, *Gallinula chloropus*, *Lxobrychus eurhythmus*, *Numenius minutus*, *Haematopus ostralegus*, *Numenius phaeopus*, *Tringa nebularia*, *Larus argentatus*, *Nycticorax nycticorax*, *Vanellus cinereus*	4.27±1.46	(2.81, 5.73)
2	8	*Numenius arquata*, *Botaurus stellaris*, *Himantopus himantopus*, *Ardea purpurea*, *Otis tarda*, *Egretta alba*, *Platalea leucorodia*, *Ardea cinerea*	12.80±2.44	(10.36, 15.24)
3	5	*Grus monacha*, *Grus grus*, *Ciconia boyciana*, *Grus vipio*, *Grus japonensis*	25.77±2.84	(22.93, 28.61)

Results

Species component

During spring migration, we recorded a total of 139 bird species of 39 families of 13 orders (Table 2), accounting for 72.77% of the total bird species recorded at Zhalong.

Dominant avian ecological group

The (Fig. 3 and Fig. 4) numbers of species by ecological group during spring migration at Zhalong were Passeres > Grallatores > Natatores > Raptatores > Scansores > Terrestores, and the numbers of birds were Grallatores > Natatores > Passeres > (Raptatores + Terrestores + Scansores). Grallatores, Natatores and Passeres were the three main ecological groups.

Use of different water levels

The use of different water levels by different avian ecological groups showed significant differences ($p<0.01$) (Table 3). Natatores had a strong preference for water depths >30 cm water (WL4). Grallatores had a strong preference for water depths >30 cm (WL4) and 5−15 cm (WL2). Terrestores, Raptatores, Scansores and Passeres had a strong preference for no surface water (WL0). All six avian ecological groups used specific water depths, and WL0, WL2 and WL4 were preferred.

Table 2. Species composition of avian community during spring migration in Zhalong

Species	EG	Species	EG	Species	EG	Species	EG
PODICIPEDIFORMES		GALLIFORMES		CUCULIFORMES		PASSERIFORMES	
(1) Podicipedidae		(8) Phasianidae		70.*Cuculus canorus*	S	101.*Corvus corone*	P
1.*Tachybaptus ruficollis*	N	36. *Perdix dauuricae*	T	71.*Cuculus saturatus*	S	(29) Prunellidae	
2.*Podiceps nigricollis*	N	37.*Coturnix coturnix*	T	STRIGIFORMES		102.*Prunella montanella*	P
3.*Podiceps cristatus*	N	38.*Phasianus colchicus*	T	(18) Strigidae		(30) Turdidae	
4.*Podiceps grisegena*	N	(9) Gruidae		72.*Asio otus*	R	103.*Erithacus calliope*	P
CICONIIFORMES		39.*Grus japonensis*	G	CORACIIFORMES		104.*Erithacus svecica*	P
(2) Ardeidae		40.*Grus vipio*	G	73.*Alcedo atthis*	S	105.*Erithacus cyane*	P
5.*Ardea cinerea*	G	41.*Grus leucogeranus*	G	(20) Upupidae		106.*Tarsiger cyanurus*	P
6.*Ardea purpurea*	G	(10) Rallidae		74.*Upupa epops*	S	107.*Saxicola torquata*	P
7.*Egretta alba*	G	42.*Porzana pusilla*	G	PICIFORMES		108.*Zoothera sibirica*	P
8.*Nycticorax nycticorax*	G	43.*Porzna paykullii*	G	(21) Picidae		109.*Zoothera dauma*	P
9.*Lxobrychus sinensis*	G	44.*Gallicrex cinerea*	G	75.*Jynx torquilla*	S	110.*Turdus ruficollis*	P
10.*Lxobrychus eurhythmus*	G	45.*Fulica atra*	G	76.*Picus canus*	S	111.*Turdus naumanni*	P
11.*Botaurus stellaris*	G	CHARADRIIFORMES		77.*Picoides major*	S	(31) Paradoxornithidae	
(3) Ciconiidae		(11) Charadriidae		PASSERIFORMES		112.*Paradoxornis heudei*	P
12.*Ciconia boyciana*	G	46.*Vanellus vanellus*	G	(22) Alaudidae		(32) Sylviidae	
13.*Ciconia nigra*	G	47.*Vanellus cinereus*	G	78.*Melanocorypha mongolica*	P	113.*Cettia squameiceps*	P
(4) Threskiornithidae		48.*Charadrius dubius*	G	79.*Galerida cristata*	P	114.*Megalurus pryeri*	P
14.*Platalea leucorodia*	G	(12) Scolopacidae		80.*Alauda arvensis*	P	115.*Locustella fasciolata*	P
ANSERIFORMES		49.*Numenius minutus*	G	(23) Hirundinidae		116.*Acrocephalus orientalis*	P
(5) Anatidae		50.*Numenius phaeopus*	G	81.*Riparia riparia*	P	117.*Acrocephalus bistrigiceps*	P
15.*Branta Bernicla*	N	51.*Numenius arquata*	G	82.*Hirundo rustica*	P	118.*Phylloscopus fascatus*	P
16.*Anser cygnoides*	N	52.*Tringa nebularia*	G	83.*Hirundo daurica*	P	119.*Phylloscopus schwarzi*	P
17.*Cygnus cygnus*	N	53.*Tringa ochropus*	G	84.*Delichon urbica*	P	120.*Phylloscopus inornatus*	P
18.*Anas acuta*	N	54.*Tringa glareola*	G	(24) Motacillidae		(33) Muscicapidae	
ANSERIFORMES		55.*Tringa hypoleucos*	G	85.*Motacilla flava*	P	121.*Ficedula parva*	P
19.*Anas platyrhynchos*	N	56.*Gallinago stenura*	G	86.*Motacilla cinerea*	P	(34) Paridae	
20.*Anas poecilorhycha*	N	57.*Gallinago gallinago*	G	87.*Motacilla alba*	P	122.*Parus ater*	P
21.*Anas querquedula*	N	58.*Scolopax rusticola*	G	88.*Anthus novaeseelandiae*	P	123.*Parus palustris*	P
22.*Anas clypeata*	N	(13) Recurvirostridae		89.*Anthus godlewskii*	P	(35) Sittidae	
23.*Aythya ferina*	N	59.*Himantopus himantopus*	G	90.*Anthus hodgsoni*	P	124.*Sitta europaea*	P
24.*Aythya baeri*	N	(14) Glareolidae		91.*Anthus cervinus*	P	(36) Remizidae	
25.*Aythya fullgula*	N	60.*Glareola maldivarum*	G	(25) Bombycillidae		125.*Remiz pendulinus*	P
26.*Bucephala clangula*	N	(15) Laridae		92.*Bombycilla garrulus*	P	(37) Ploceidae	
27.*Mergus albellus*	N	61.*Larus argentatus*	G	(26) Laniidae		126.*Passer montanus*	P
FALCONIFORMES		62.*Larus ridibundus*	G	93.*Lanius bucephalus*	P	(38) Fringllidae	
(6) Accipitridae		63.*Larus saundersi*	G	94.*Lanius cristatus*	P	127.*Carduelis flammea*	P
28.*Pernis ptilorhynchus*	R	64.*Chlidonias hybrida*	G	(27) Sturnidae		128.*Loxia curvirostra*	P
29.*Buteo lagopus*	R	65.*Chlidonias leucoptera*	G	95.*Sturnus vulgaris*	P	129.*Uragus sibiricus*	P
30.*Circus cyaneus*	R	66.*Sterna hirundo*	G	96.*Sturnus cineraceus*	P	(39) Emberizidae	
31.*Circus melanoleucos*	R	COLUMBIFORMES		(28) Corvidae		130.*Emberiza aureola*	P
32.*Circus spilonotus*	R	(16) Columbidae		97.*Cyanopica cyana*	P	131.*Emberiza elegans*	P
(7) Falconidae		67.*Columba rupestris*	T	98.*Pica pica*	P	132.*Emberiza spodocephala*	P
33. *Falco rusticolus*	R	68.*Columba livia*	T	PASSERIFORMES			
34.*Falco columbarius*	R	69.*Streptopelia orientalis*	T	99.*Corvus dauurica*	P		
35.*Falco amurensis*	R	(17) Cuculidae		100.*Corvus macrorhynchos*	P		

Note: EG is ecological group; N is Natatores, G is Grallatores, T is Terrestores, R is Raptatores, S is Scansores, P is Passeres.

Use of different habitat types

There was significant difference in use of habitat types by different avian ecological groups during (p<0.01) (Table 4). Natatores preferred water bodies, Grallatores preferred reed marsh and water bodies, Terrestores preferred reed marsh and farmland, Raptatores and Passeres preferred reed marsh and open forest, Scansores preferred open forest. All six avian ecological groups had preferred habitat types; lake, reed marsh, farmland and open forest were their preferred habitat types.

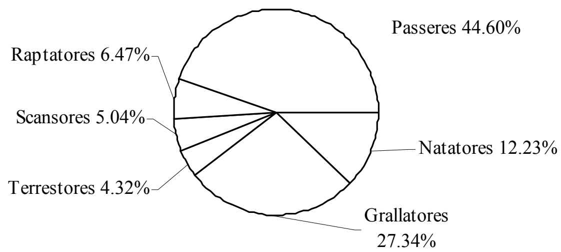

Fig. 3 Distribution of avian species within ecological groups during the spring migration in Zhalong reserve

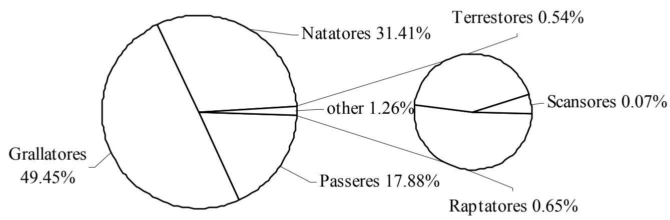

Fig. 4 Distribution of avian population within ecological groups during the spring migration in Zhalong reserve

Table 3. Use of different water level by avian ecological groups during spring migration at Zhalong reserve

	Natatores	Grallatores	Terrestores	Raptatores	Scansores	Passeres
WL0	1.461	2.803	73.984*	67.347*	87.500*	61.580*
WL1	0.689	3.115	13.821	4.762	12.500	5.753
WL2	1.433	22.530*	6.504	12.245	0.000	14.790
WL3	2.979	3.687	3.252	10.204	0.000	7.309
WL4	93.437*	67.866*	2.439	5.442	0.000	10.568
χ^2	338.424	155.782	186.700	142.556	55.693	110.634
P	0.000	0.000	0.000	0.000	0.000	0.000

Note: WL is water level, WL0 is no surface water, WL1 is 1- 5 cm, WL2 is 5-15 cm, WL3 is 15-30 cm, WL4 is more than 30cm.

Table 4. Use of different habitat types by avian ecological groups during the spring migration in Zhalong reserve

	meadow steppe	water area	reed marsh	farmland	carex swamp	open forest	χ^2	P
Natatores	1.124	91.863*	6.577	0.112	0.281	0.042	155.42	0
Grallatores	0.669	22.057*	75.676*	0.187	1.285	0.125	150.48	0
Terrestores	4.878	3.252	44.715*	34.146*	3.252	9.756	99.44	0
Raptatores	4.082	0	40.136*	8.163	6.122	41.497*	72.556	0
Scansores	0	0	12.5	6.25	0	81.250*	102.98	0
Passeres	4.691	6.79	41.901*	12.395	1.951	32.272*	80.6	0

Habitat preference

Different avian ecological groups had different preferences for water depths (Table 5). Among, the preferred habitat of Natatores was water area with deep water level (>30 cm) (WL4). Grallatores preferred reed marsh and water bodies with >30 cm (WL4) and 5−15 cm (WL2) water depth. Terrestores preferred reed marsh with no surface water and farmland (WL0). Raptatores and Passeres preferred open forest and reed marsh with no surface water. Scansores preferred open forest (WL0).

There were significance differences in the overlap distribution area of different avian ecological groups. Lakes with >30 cm water depth were the overlap distribution area between Natatores and Grallatores, reed marsh with no surface water was used by Terrestores, Raptatores and Passeres, and open forest was used by Raptatores, Scansores and Passeres.

Table 5. Preferred habitats of ecological groups during the spring migration season at Zhalong reserve

Avian ecological group	Water level	Habitat type
Natatores	WL4	water area
Grallatores	WL4>WL2	reed marsh> water area
Terrestores	WL0	reed marsh> farmland
Raptatores	WL0	open forest >reed marsh
Scansores	WL0	open forest
Passeres	WL0	reed marsh>open forest

Note: WL is water level, WL0 is no surface water, WL1 is 1- 5 cm, WL2 is 5-15 cm, WL3 is 15-30 cm, WL4 is more than 30cm.

Discussion

Species component

Species number recorded in the present study is far less than the previous record (Gao 1989; Wu 1999). There are the three possible reasons. The first reason is the study period. The study period for this research was March to May, only a quarter of a year or a third of the main life history stage for birds at Zhalong (March to November). This was probably the main reason. The second reason is the study area, which was only the main distribution area of birds at Zhalong, but not the entire reserve area. Thus birds and species in unsampled areas were not recorded. The third reason is the study technology. Although the investigation method of this paper was approved to be a general method for avian community investigation (Buckland *et al*. 2001; Sara 2001; Cai *et al*. 2010), some technical defects might have reduced records of birds or species.

Dominant avian ecological group and habitat use

Natatores, Grallatores and Passeres were the three main ecological groups during spring migration at Zhalong. The dominant vegetation in the reserve is wetland vegetation (reed marsh and water area), which are the main habitats of Grallatores and Natatores. It was inevitable that Grallatores and Natatores became the dominant ecological groups recorded in the reserve. Passeres is the main avian ecological group in northeast China (Zhao 1988); and the present study showed a consistent result. The dominant vegetation types and geographic region influenced the distribution of dominant avian ecological group during spring migration at Zhalong.

Preference habitat

Passeres, Grallatores and Natatores showed a gradient in numbers according to water level. Grallatores was recorded in the transitional stages of water levels and habitat types. The wetland environment quality in the reserve would be in the state of regression when the species number and abundance of Passeres increases. Conversely, when the species number and abundance of Natatores increase, we can conclude that the wetland has adequate water supply. The various avian ecological groups had specific water level preferences, and overlapped distribution during spring migration at Zhalong. So, we can monitor the wetland quality in a reserve by monitoring the species and its population of Passeres and Natatores.

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